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# LIFE CYCLE ASSESSMENT MODELLING CONSIDERING IMPURITIES IN RECYCLABLE MATERIALS

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After direct reuse, recycling of materials at end-of-life is promoted by the European Union as an efficient path to resource recovery. However, although new and up-to-date technologies exist that allow the sorting of recyclables from mixed materials, impurities in the fraction streams still constitute a main obstacle to efficient recycling. Impurities occur in waste fractions as missortings or unintended contaminants. The first term refers to external materials disposed in the wrong bin (e.g. ceramics in the glass fraction). Conversely, the second term indicates waste products whose composition does not allow a unique fraction classification (e.g. nanomaterials in the metal fraction). Indeed, new technological development creates new versatile properties but also unintended disposal problems due to the broad diversity in product's composition. The recycling rate of different waste categories (e.g. plastic, metal, paper, glass) is generally defined by municipalities or waste companies as the amount of waste (by weight) which is sent to recycling facilities. As it does not represent the amount de facto recycled, the upcoming European Union directive on Circular Economy is expected to make a change to such definition, moving to a recycling rate calculation that also considers the presence of impurities in material streams. This will inevitably lead to lower recycling rates, as the impurities will not be considered as recycled.

The objectives of this study are to evaluate (i) how the presence of impurities may affect the quality of recovered recyclables collected at recycling centres, and (ii) how these impurities are modelled in LCA studies in literature.

As input to the evaluation, a review of relevant LCA studies was performed to evaluate approaches for addressing impurities in waste fractions collected for recycling. It was found that the occurrence of impurities is typically not modelled in the studies. The influence of source separation is modelled via sensitivity analysis by some authors (Rigamonti 2009, Bernstad 2011, Boldrin 2011), but the general trend is that impurities are not considered. It was found that LCA studies which are not considering the presence of impurities in materials sent to recycling processes lead to four major consequences: (i) assuming collected material amounts as pure, real quantities available for a second life may be overestimated (material losses during recycling of paper fluctuate from 2% in Manfredi 2011, through 9-14% in Bernstad 2011, to 16% in Merrild 2012); (ii) processing problems may arise in the case of bad quality sorted fractions, like damages to machines or interruptions to production (Ruben Miranda 2013); (iii) recycling processes may result in lower yields and finished products may lead to reduced value (downcycling instead of recycling); (iv) contaminants may be unintentionally recycled within global waste recycling streams (risk-cycling). These four aspects suggest that the environmental benefits claimed by LCA studies ignoring the presence of impurities in recyclables' streams may be higher than in reality.

To further promote a discussion about the importance of considering impurities in LCA, preliminary data from a sorting study at a recycling center in Denmark will be presented to highlight the need for a better modelling of these aspects in LCA.

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